Introduction to MISR Data Analysis and Tools

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Exploring and Using MISR Data
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SOM Background

Figure A-3 Sample Partial MISR Swath in SOM vs. Distorted Geographic Lat/Lon

SOM on the left exhibits minimal distortion at all latitudes, whereas the Geographic Lat/Lon projection on the right exhibits much greater distortion in size and shape at high latitudes (towards the top.)
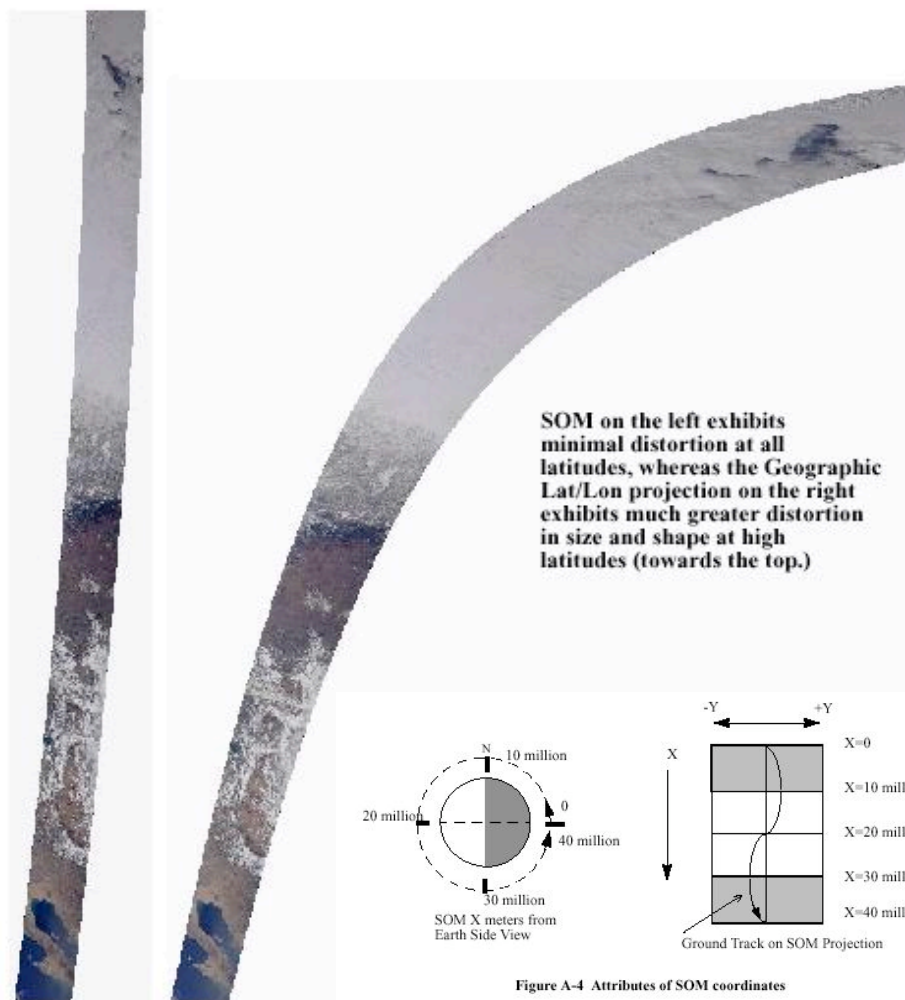
Figure A-4 Attributes of SOM coordinates

The Space Oblique Mercator (SOM) map projection was developed to support LandSat which covers the same large geographic extent as MISR.

SOM was designed to minimize the shape distortion and scale errors throughout the length of the MISR swath near the satellite ground track.

SOM X is in the direction of the Spacecraft ground track and SOM Y is perpendicular X

SOM Background

- Terra follows a pattern of orbits which repeats after 233 unique orbits

- Each of the 233 possible orbits is called a path

- SOM defines a separate projection for each of these paths

- For MISR, a path begins at a particular longitude as the satellite crosses the ascending node.

- This path implies a specific longitude of ascending node, which implies a specific SOM projection applicable to that path
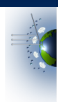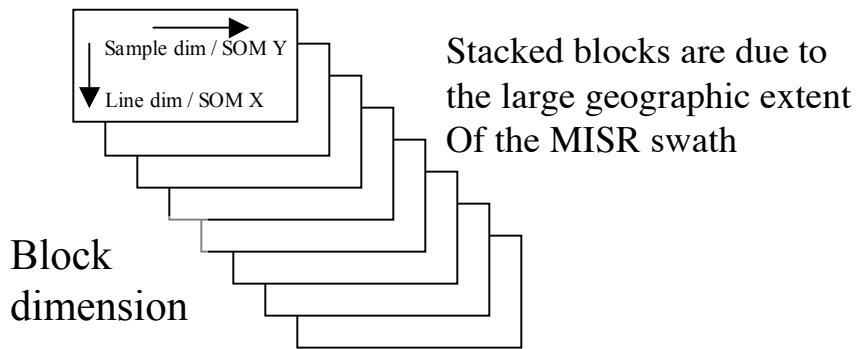
MISR Orbital Paths/Blocks

MISR orbit - An_mar21_233_1426 (Day 1)
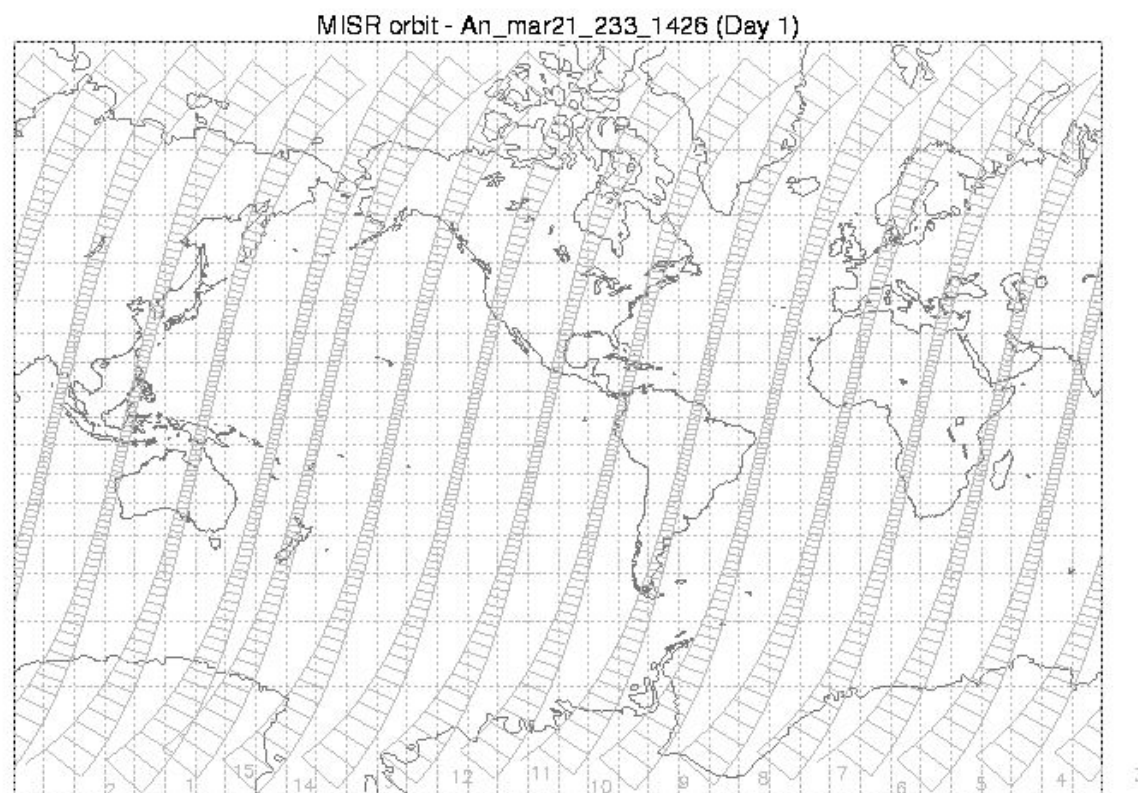
MISR HDF-EOS "Stacked Block" File vs. Aligned File

Standard Product Files are "Stacked-Block"

Conventional Product Files & Browse Product Files are Aligned

Red Channel Grid SDS (180 Stacked Blocks)

Sample dim / SOM Y

Line dim / SOM X

Stacked blocks are due to the large geographic extent Of the MISR swath

Block dimension

-SOM coordinates of top-block corners part of Grid metadata.

-Projection and orbital parameters part of Grid Metadata

-Offsets of each block from the one above is part of Stacked-block grid extension metadata.

059

060

061

062

063

MISR HDF-EOS "Stacked Block" Background

- HDF-EOS routines do NOT assemble the blocks. That is left for the user or the MISR Toolkit

- 180 blocks are defined for every MISR Product to make block index absolute

- However, roughly 142 blocks have data for any given orbit. The extra blocks are to allow for seasonal variation

- A Conventional Grid Product that does not use "stacked-block", but rather a conventional HDF-EOS format is now available via the MISR order tool

- We will, however, preserve "stacked-block" Standard Product in processing

Diagram representing the 180 block series covering a MISR path.
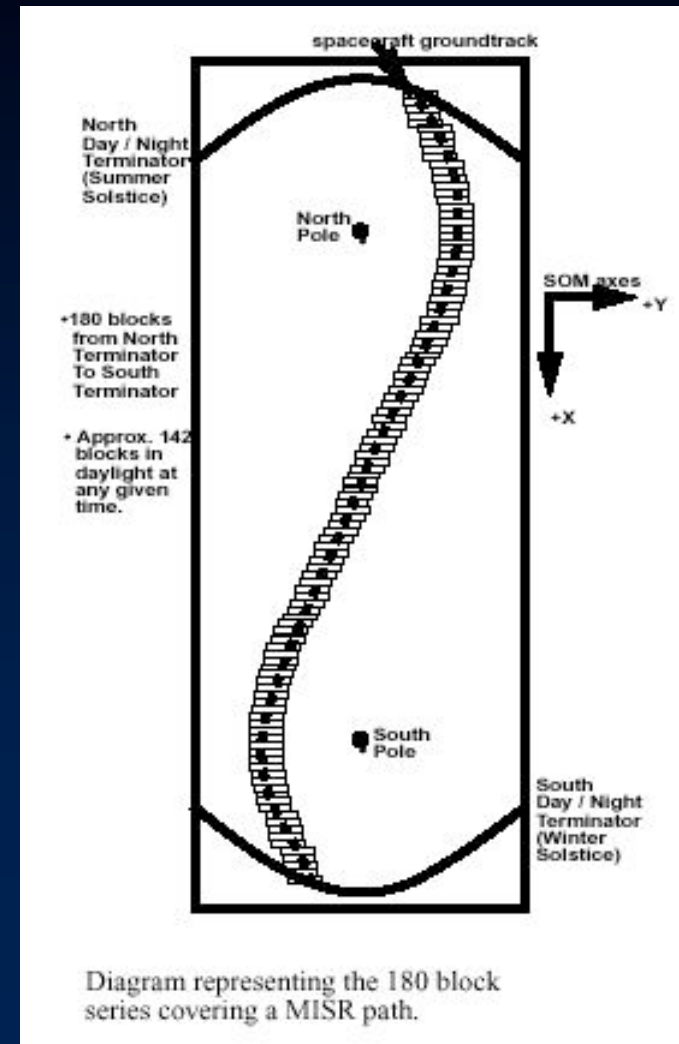
Where does this pixel belong with the MISR HDF-EOS "Stacked Block" Scheme?

- Inside the HDF-EOS "stacked block grid" = (block, line, sample)

- Convert (block, line, sample) <-> SOM (x,y)

  - Requires several metadata values and some arithmetic.

- Convert SOM (x,y) <-> Lat/Lon

  - Requires use of GCTP map projection coordinate conversion library in HDF-EOS distribution.

- Units: Integral block, fractional line/sample; meters x/y; decimal degrees Lat/Lon.

- This process is described in the <u>MISR Data Product Specification</u>, Appendix A and also routines are provided in the MISR Toolkit.

- Or simply look up the Lat/Lon of the corresponding block, line, sample in the Ancillary Geographic Product (AGP) datasets (1.1km).

What is the MISR "Conventional Grid" Product?
Standard HDF-EOS Grid

Simplified format

- Eliminates stacked-blocks.
- Files are still HDF-EOS.
- Same SOM map projection.
- Same spatial resolutions, grid names, field names, and meta-data.
- Approximately same file sizes.
- Most data is gridded identically to original input file => no resampling => identical data numbers.
- Only exception is 35.2 and 70.4 km grids, which require resampling.
- Better tool support.

Stacked-block format

X Y
block 1

block

block n

HDFView - L1B2 Imagery
"MISR Conventional Grid" Products ordered via the MISR order tool

MISR Browse Tool

http://eosweb.larc.nasa.gov/MISRBR/

MISR L1B2 Browse Product
JPEG true-color imagery, all 9 cameras, 2.2 km sampling
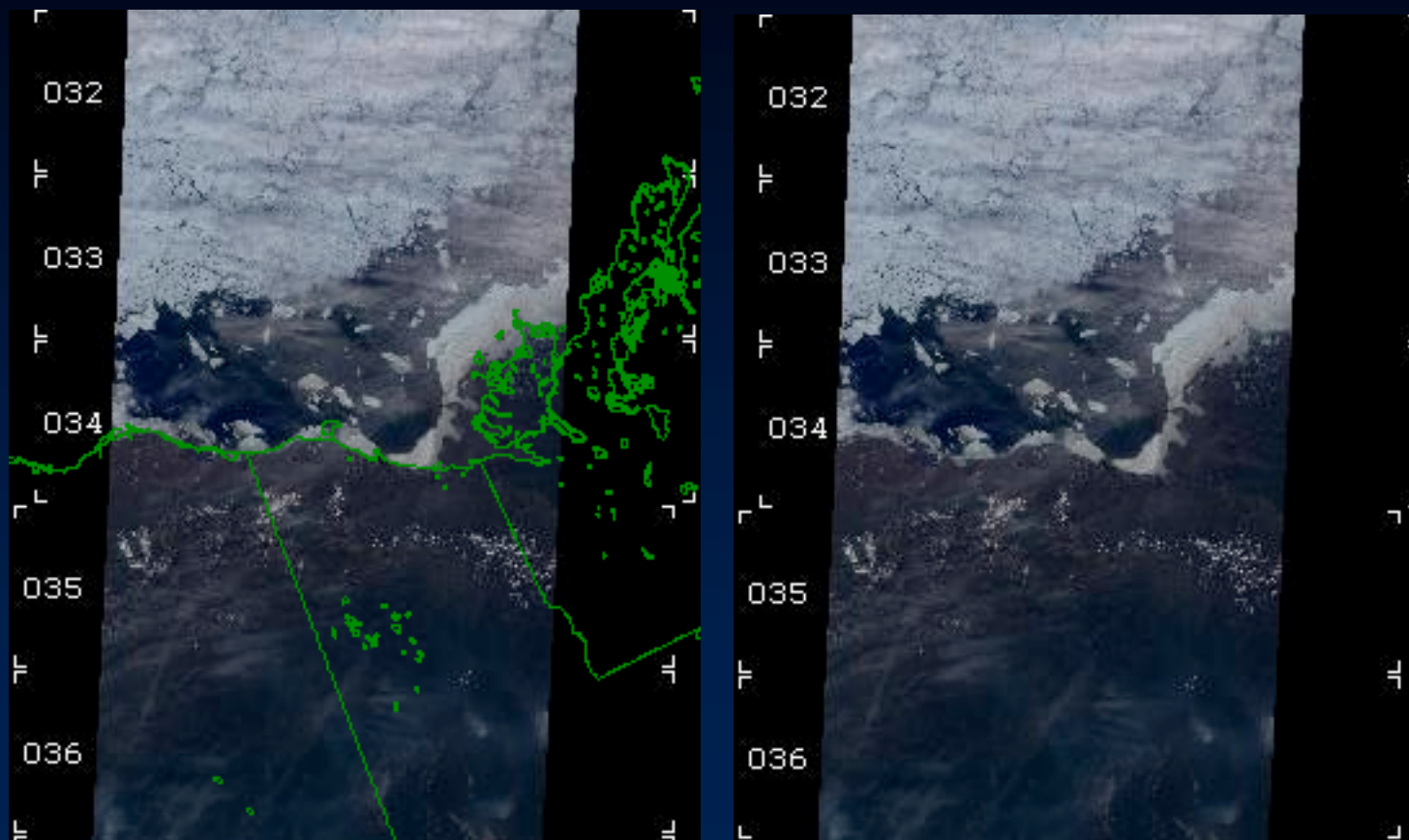
MISRView
For the "Stacked Block" Products

- Maps path/orbit to time and date
- Assembles MISR blocks
- Reports Lat/Lon using the AGP
- Displays true color MISR imagery
- Can reproject MISR imagery
- Requires IDL or IDL VM

- Perspective tool
- Band slider tool
- Scroll tool
- Vector overlay tool
- Reprojection tool
- Color / Contrast tools

MISRView – Main Menu

MISRView – L1B2 imagery

MISRView – MISR Vision (R-Ba, G-An, B-Bf)
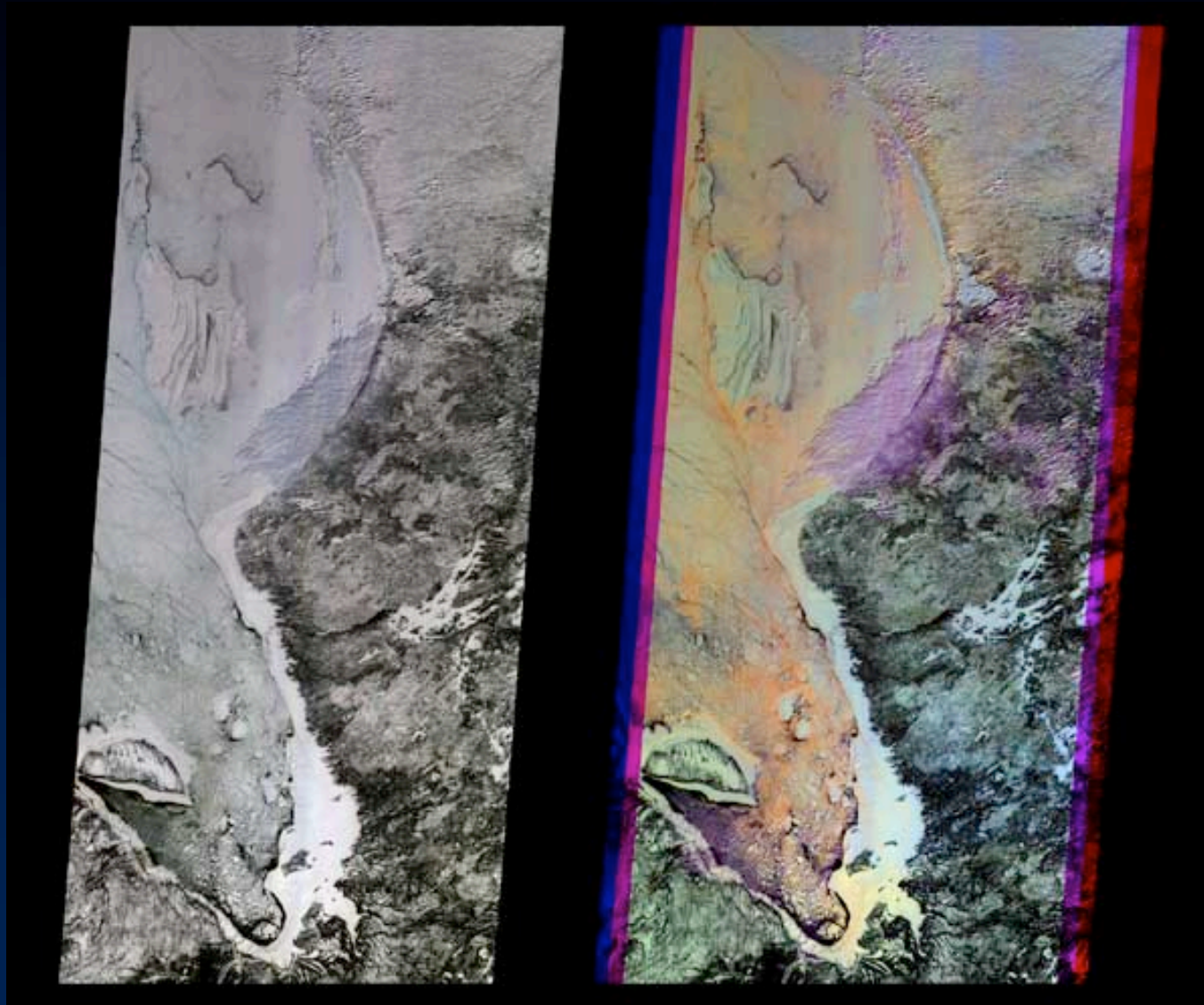
MISR INteractive eXplorer (MINX)

A interactive application that functions both as a general-purpose tool to visualize MISR data and as a specialized tool to analyze properties of smoke, volcanic and dust plumes

It includes high-level options to create:

- Map views of MISR orbit locations

- Scrollable, single-camera, RGB images of MISR level 1B2 (L1B2) radiance data

- Animations of the nine MISR camera images that provide a 3D perspective of the scenes that MISR has acquired

Some of the specialized options in MINX enable the user to:

- Display plots of top-of-atmosphere BRF vs. camera-angle for pixels you click on

- Save images and animations to disk in various formats

- Apply a geometric registration correction to warp camera images when the standard processing correction is inadequate

- Difference the images of two MISR orbits that share a path (identical ground track)

- Construct pseudo-color images by assigning different combinations of MISR cameras to the RGB display channels

- Interactively digitize smoke, volcanic or dust plumes and automatically retrieve heights and winds, albedos, aerosol properties and fire power and brightness temperatures associated with those plumes
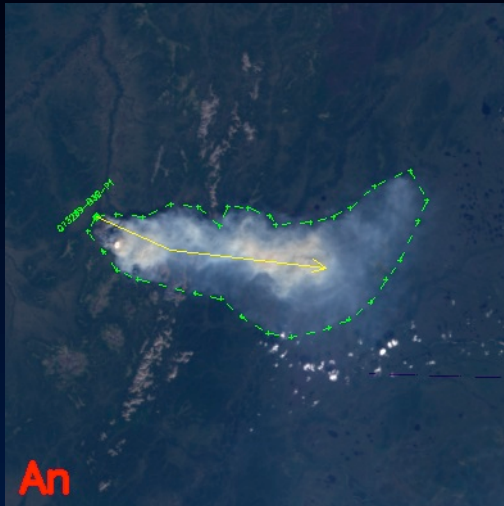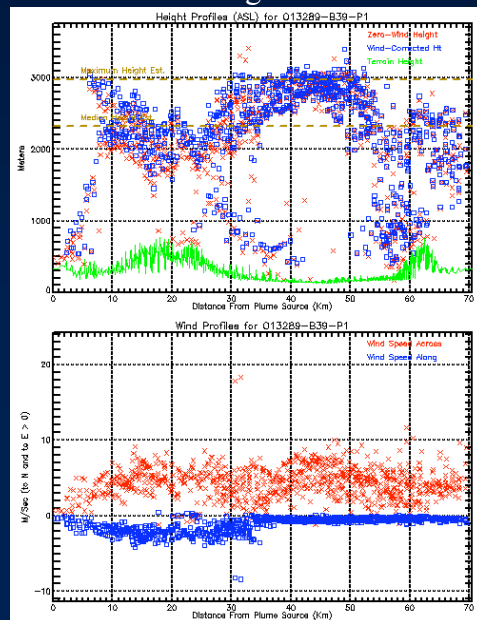
http://www.openchannelfoundation.org/projects/MINX/

MISR INteractive eXplorer (MINX)

Program Options

MISRVision

Camera Ratios

Orbit Plot

Animation Window

MISR INteractive eXplorer (MINX)

Digitized Plume Points

Wind Height Histogram
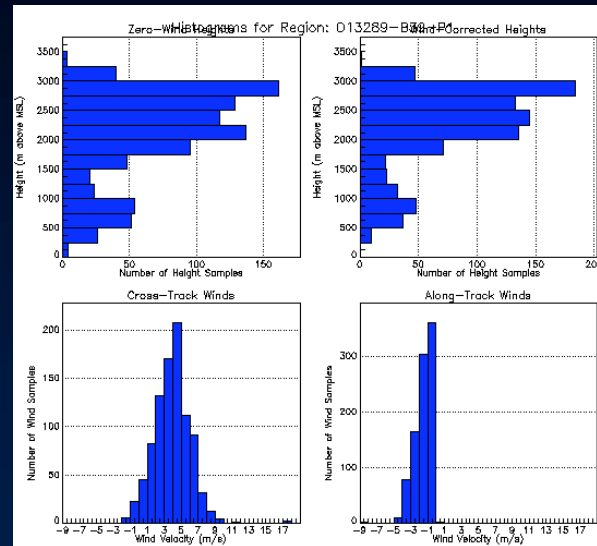
Aerosol Histogram

Wind & Height Profiles
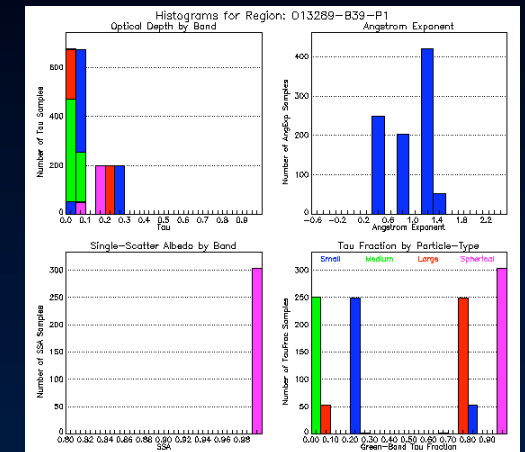
Albedo Profile

Plume Height Contour
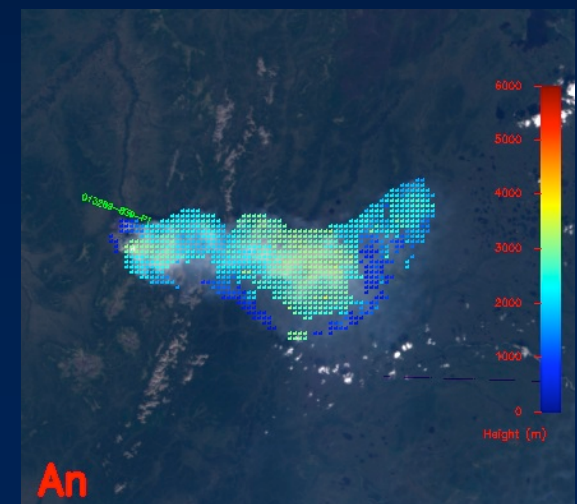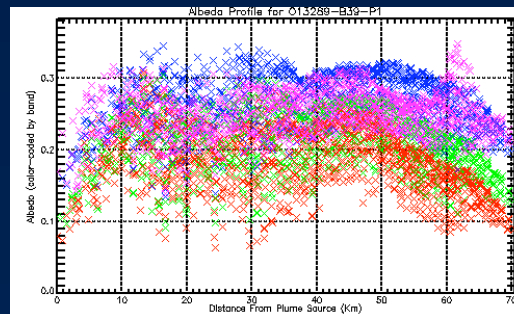
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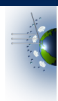
MISR INteractive eXplorer (MINX)
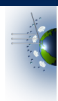
MISR INteractive eXplorer (MINX)
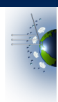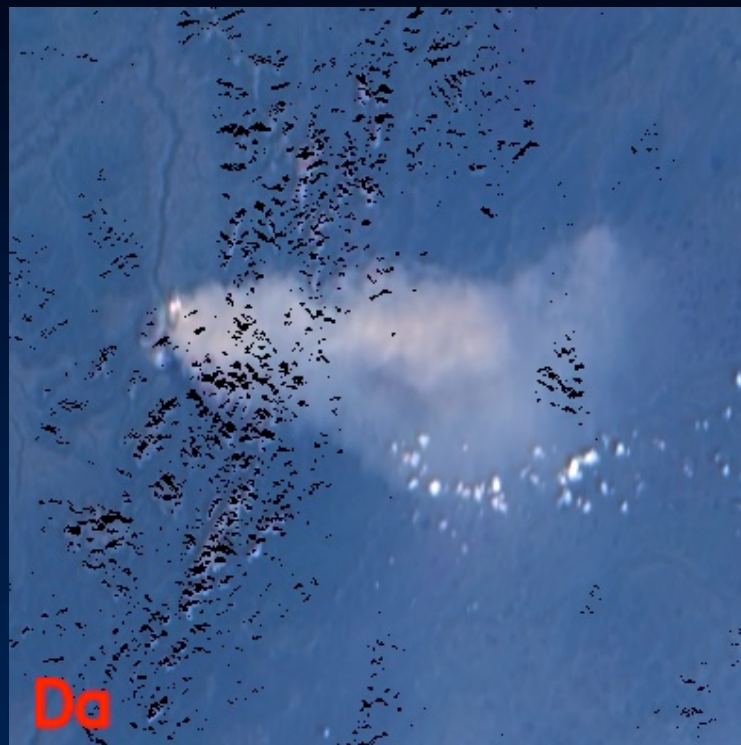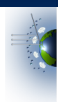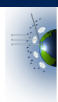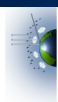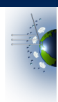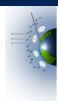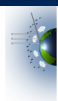
MISR Level 3 Overview Web Page

- http://eosweb.larc.nasa.gov/PRODOCS/misr/level3/overview.html

- Can view jpegs of all available Level 3 data.
- Can view by product and by month or season.
- Can view animation through a year's worth of data.
- Can directly download Level 3 HDF files.
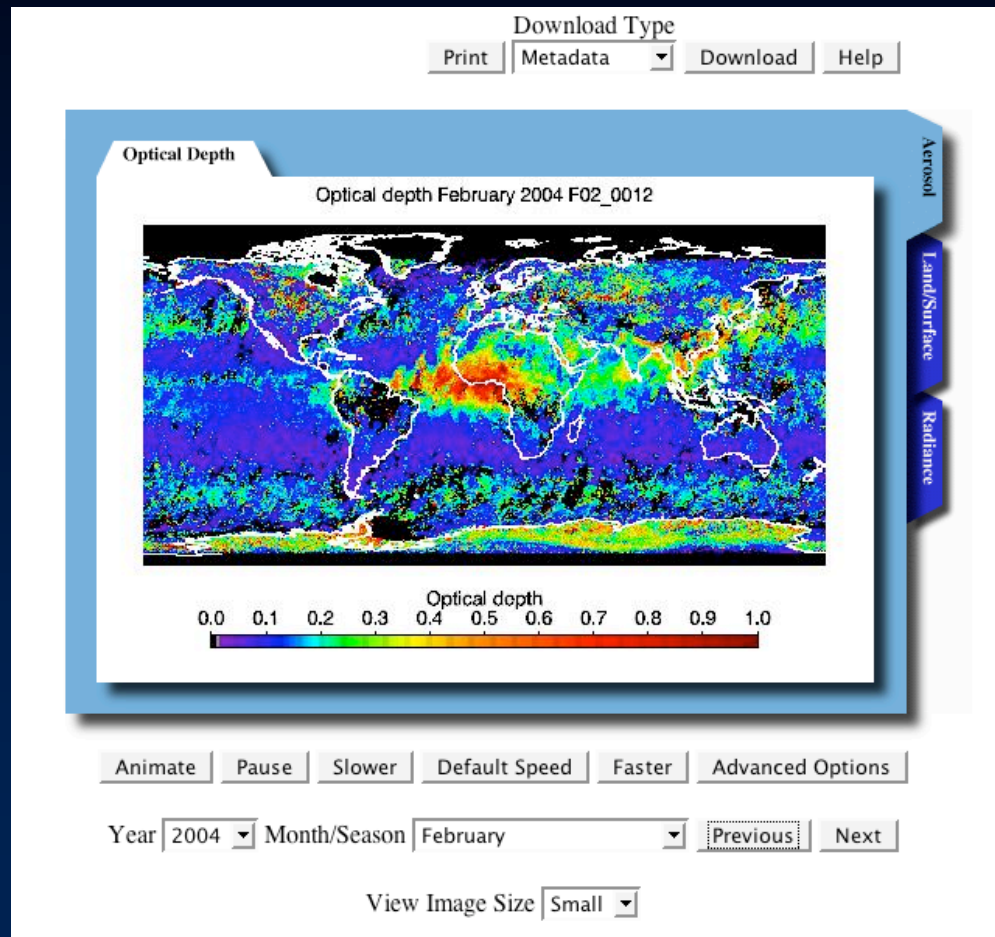
MISR Level 3 Data File Format

- Level 3 data files
    - In standard HDF-EOS grid format.
    - Not in more complicated "stacked block" grid used by Level 1 and Level 2.
    - Can be read by any tool that knows HDF-EOS (i.e, IDL).
    - To simply view data, use Level 3 web page - no need to work with HDF-EOS file.
    - Level 3 HDF-EOS data files can be downloaded directly from the overview web page.
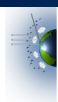
Aerosol Measurement and Processing System

AMAPS is a community-based distributed analysis environment for aerosol science. It is a collaborative project with three partners: the Jet Propulsion Laboratory (JPL), the University of Michigan (UM), and NASA's Langley Atmospheric Sciences Research Center (LaRC).

The figure illustrates the AMAPS concept:

• A virtual workspace in which executable "operators" can be invoked on any member data set regardless of actual physical locations of data, operators and users.

• AMAPS uses the SciFlo grid workflow engine to call remote operators (web services), pass arguments to them, and/or move code and data over the world-wide web in whatever order or configuration is most efficient.

• This makes access to data easier, allows users to build on and reuse each other's operators, and increases computational power.

http://df3.jpl.nasa.gov or http://amaps.jpl.nasa.gov
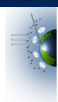
Aerosol Measurement and Processing System

Service users access AMAPS capabilities through web pages that display predefined SciFlo workflows

MisrSubsetter Workflow

Input Web Page

OutPut Web Page

Processing Web Page

Aerosol Measurement and Processing System

<u>Power users</u> author their own XML documents, bypassing the web interface

<u>Power users capabilities</u>:

• Have the flexibility to create their own executables in python (and eventually in any language or package of their choice)

• Can chain together with existing AMAPS operators, web services, and even other workflows

• Execute their workflows from the command line on any computer equipped with AMAPS software

• Such a computer is called an AMAPS node

• Presently there are three AMAPS nodes: one at JPL, one at the University of Michigan, and one at LaRC

<u>Four key technologies are at the heart of AMAPS</u>:

• Python programming language

• XML standard

• Simple Object Access Protocol (SOAP)

• SciFlo grid workflow system

Introduction to the MISR Toolkit API

- The MISR Toolkit API provides simplified MISR data access and geolocation functionality utilizing the GCTP metadata, instead of an ancillary data set lookup

- Abstract MISR "stacked block HDF-EOS grid" to a geolocated SOM projected plane with blocks assembled and fields unpacked and unscaled

- Reads MISR L1B2, L2 and Conventional products

- There are no other tools available that simultaneously make use of the GCTP geolocation metadata and are aware of the MISR "stacked block" format for all of the MISR products

MISR Toolkit
(geolocated plane)

HDF-EOS2
(grid/stacked block)

HDF4   **GCTP**
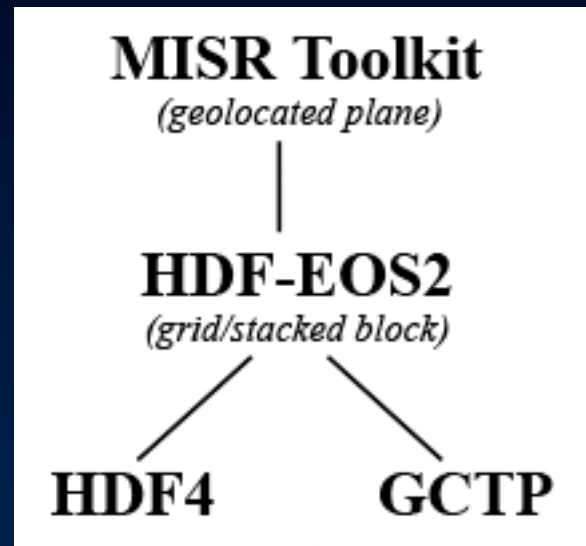
MISR Toolkit API Overview
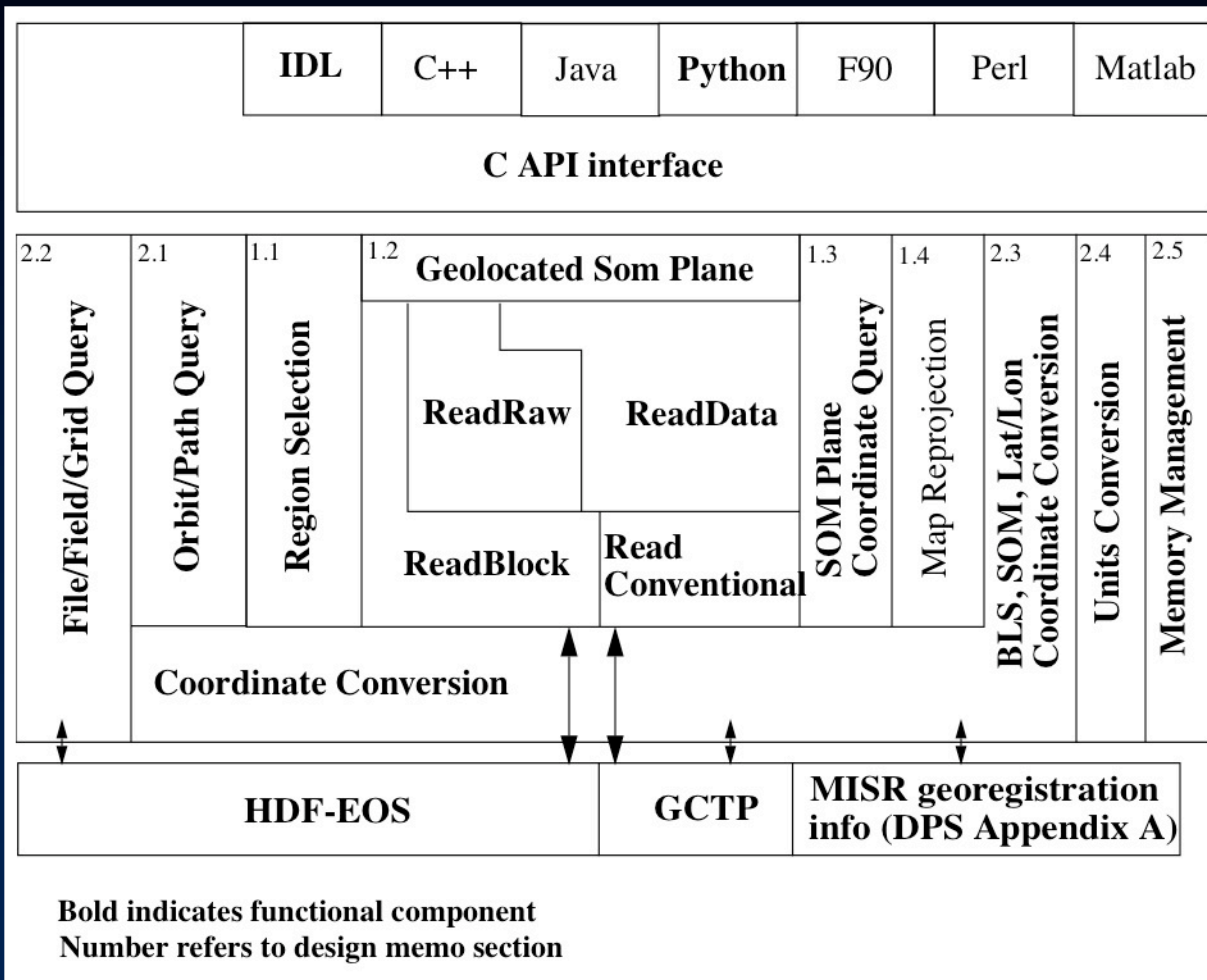
MISR Toolkit API Components (Partial List)

1.1) **Region Selection**

MtkSetRegionByUlcLrc()
MtkSetRegionByLatLonExtent()
MtkSetRegionByPathBlockRange()

1.2) **Reading a Geolocated SOM plane**

MtkReadData()
MtkReadRaw()
MtkReadBlockRange()

1.3) **SOM Plane Coordinate Query**

MtkLSToLatLon()
MtkLatLonToLS()
MtkLSToSomXY()
MtkSomXYToLS()

1.4) **Map Reprojection**

TBD

2.1) **Orbit/Path Query**

MtkLatLonToPathList()
MtkRegionToPathList()
MtkTimeToOrbitPath()
MtkTimeRangeToOrbitList()
MtkPathTimeRangeToOrbitList()
MtkOrbitToPath()

2.2) **File/Grid/Field Query**

MtkMakeFilename()
MtkFindFileList()
MtkFileToGridList()
MtkFileGridToFieldList()

2.3) **Coordinated Conversion**

MtkPathToProjParam()
MtkLatLonToBls()
MtkBlsToLatLon()
MtkSomXYToBls()
MtkBlsToSomXY()
MtkLatLonToSomXY()
MtkSomXYToLatLon()

2.4) **Unit Conversion**

MtkDmsToDd()
MtkDdToDms()
MtkDdToRad()
MtkRadToDd()
MtkDmsToRad()
MtkRadToDms()

2.5) **Memory Management**

MtkDataBufferAllocate()
MtkDataBufferFree()

MISR Toolkit API Concept
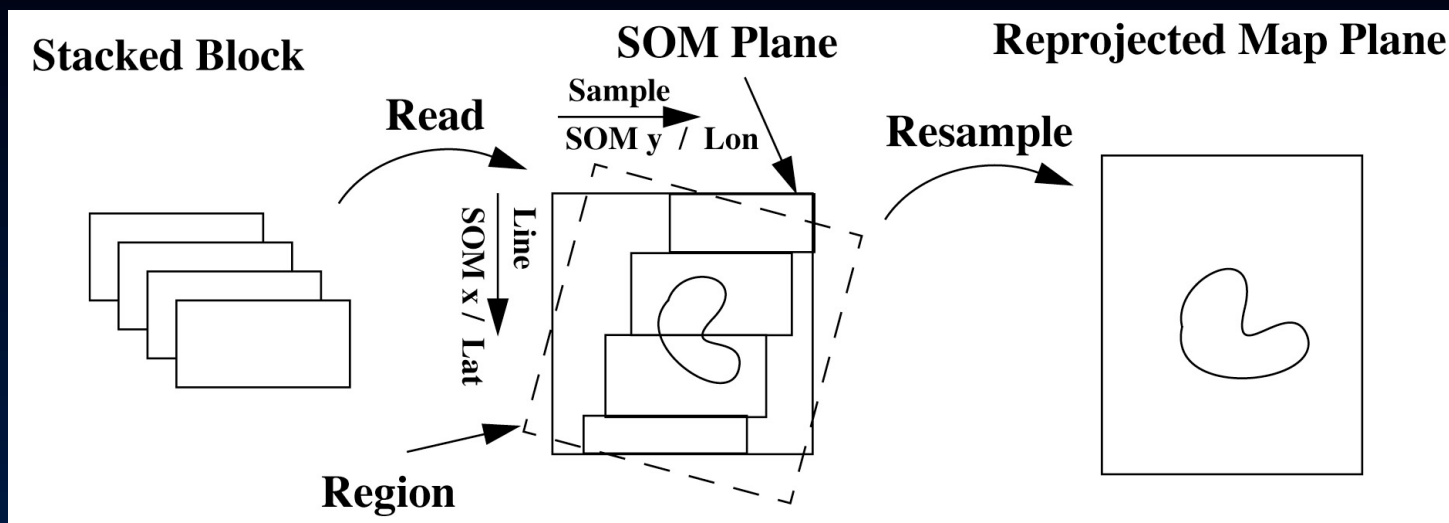
1) Select a geographic region of interest
2) Read a geolocated SOM plane from any number of MISR product files using the selected region. The region will be "snapped" to the geolocated SOM grid determined by the path number of the product
3) Query the coordinates of the SOM plane, mapping between plane line/sample, SOM x/y, Latitude/Longitude and "stacked-block" block, line, sample

Note: Adjacent paths are actually separate SOM projections, so a map re-projection may be needed to compare between separate MISR paths
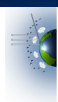
SetRegion, ReadData, MapQuery & CoordQuery

1) mtk_setregion_by_latlon_extent(29.15, -112.2, 150, 100, "km", region)

2) filename = "MISR_AM1_GRP_ELLIPSOID_GM_P037_O029058_AA_F03_0024.hdf"

3) mtk_readdata(filename, "RedBand", "Red BRF", region, red, redmap)
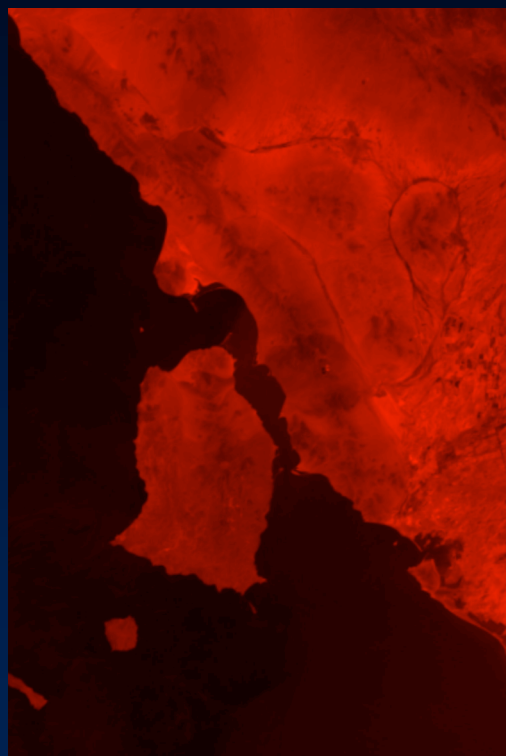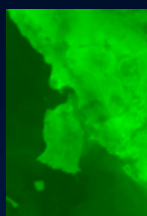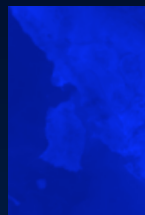
4) mtk_readdata(filename, "GreenBand", "Green BRF", region, grn, grnmap)

5) mtk_readdata(filename, "BlueBand", "Blue BRF", region, blu, blumap)

6) img = [[[red]],[[rebin(grn,ns,nl)]],[[rebin(blu,ns,nl)]]]

7) mtk_ls_to_latlon(redmap, 0, 0, ulclat, ulclon)

8) mtk_ls_to_latlon(redmap, redmap.nline, redmap.nsample, lrclat, lrclon)

9-12) mtk_dd_to_deg_min_sec(ulclat/ulclon/lrclat/lrclon, deg, min, sec)

13) mtk_ls_to_latlon(redmap, 288, 192, lat, lon)

14) mtk_latlon_to_ls(redmap, lat, lon, line, sample)

15) mtk_ls_to_somxy(redmap, 288, 192, somx, somy)

16a) mtk_latlon_to_bls(37, 275, lat, lon, block, line, sample)

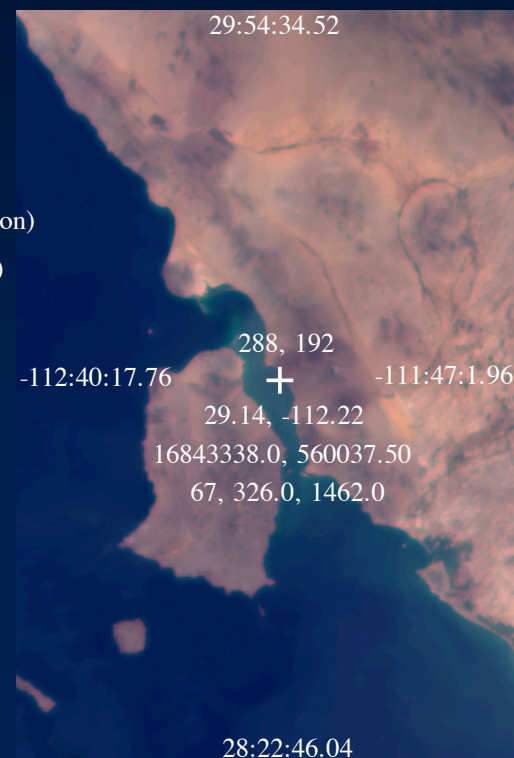16b) mtk_somxy_to_bls(37, 275, somx, somy, block, line, sample)

17) mtk_region_to_pathlist(region, pathcnt, pathlist)
    pathcnt = 5   pathlist = 34 35 36 37 38

18) mtk_path_timerange_to_orbitlist(37, '2005-12-01T00:00:00Z', '2005-12-31T23:59:59Z', orbitcnt, orbitlist)
    orbitcnt = 2   orbitlist = 31854 32087

19) mtk_path_timerange_to_orbitlist(38, '2005-12-01T00:00:00Z', '2005-12-31T23:59:59Z', orbitcnt, orbitlist)
    orbitcnt = 2   orbitlist = 31723 31956

20) mtk_orbit_to_path(31723, path)
    path = 38

29:54:34.52

288, 192

-112:40:17.76   +   -111:47:1.96

29.14, -112.22

16843338.0, 560037.50

67, 326.0, 1462.0

28:22:46.04

Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

MISR Toolkit API Concept (cont.)

In addition to L1B2, L2 and Conventional MISR data access the MISR toolkit has the ability to

- Perform coordinate conversions between lat/lon <->SOM x/y <-> line/sample <-> block/line/sample
- Inter-compare MISR data with other data sets geographically
- Query a MISR product file to retrieve such information as block range, file version, file type, grid list, field list (including unpacked/unscaled fields), dimension list, metadata, etc.
- Construct MISR filenames and search a directory tree for the file
- Convert between path, orbit and time range
- Determine which paths/orbits cross a particular geographic location or region within a given time range
- Read a stack of blocks without assembling them (with the coordinate conversion capability, determining geolocation is trivial)

FileQuery, OrbitPath, CoordQuery & MapQuery

MISR Toolkit Platform and Language Availability

Platforms and Languages Available (version 1.2)

- C library on Linux, Mac OS X and Windows XP

- IDL on all platforms via dynamically loadable library

- Python bindings for Linux and Mac OS X

- Command line utilities on Linux and Mac OS X (Useful for scripting or function usage examples)

http://www.openchannelfoundation.org/projects/MISR_Toolkit/

MISR Toolkit IDL example to convert to ENVI

```
pro convert2envi, filename, envifilename

  path = 0
  status = mtk_file_to_path(filename, path)
  if (status ne 0) then exit

  status = mtk_file_to_blockrange(filename, start_block, end_block)
  if (status ne 0) then exit

  status = mtk_file_to_gridlist(filename, ngrid, gridlist)
  if (status ne 0) then exit
  gridname = gridlist[0]

  status = mtk_file_grid_to_fieldlist(filename, gridlist[igrid], nfield, fieldlist)
  if (status ne 0) then exit
  fieldname = fieldlist[0]

  status = mtk_file_grid_field_to_dimlist(filename, gridname, fieldname, ndim, dimnames, dimsizes)
  if (status ne 0) then exit

  status = mtk_setregion_by_path_blockrange(path, start_block, end_block,region)
  if (status ne 0) then exit

  status = mtk_readdata(filename, gridname, fieldname, region, databuf, mapinfo)
  if (status ne 0) then exit

  status = mtk_write_envi_file(envifilename, databuf, mapinfo, filename, gridname, fieldname)
  if (status ne 0) then exit

end
```
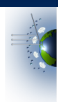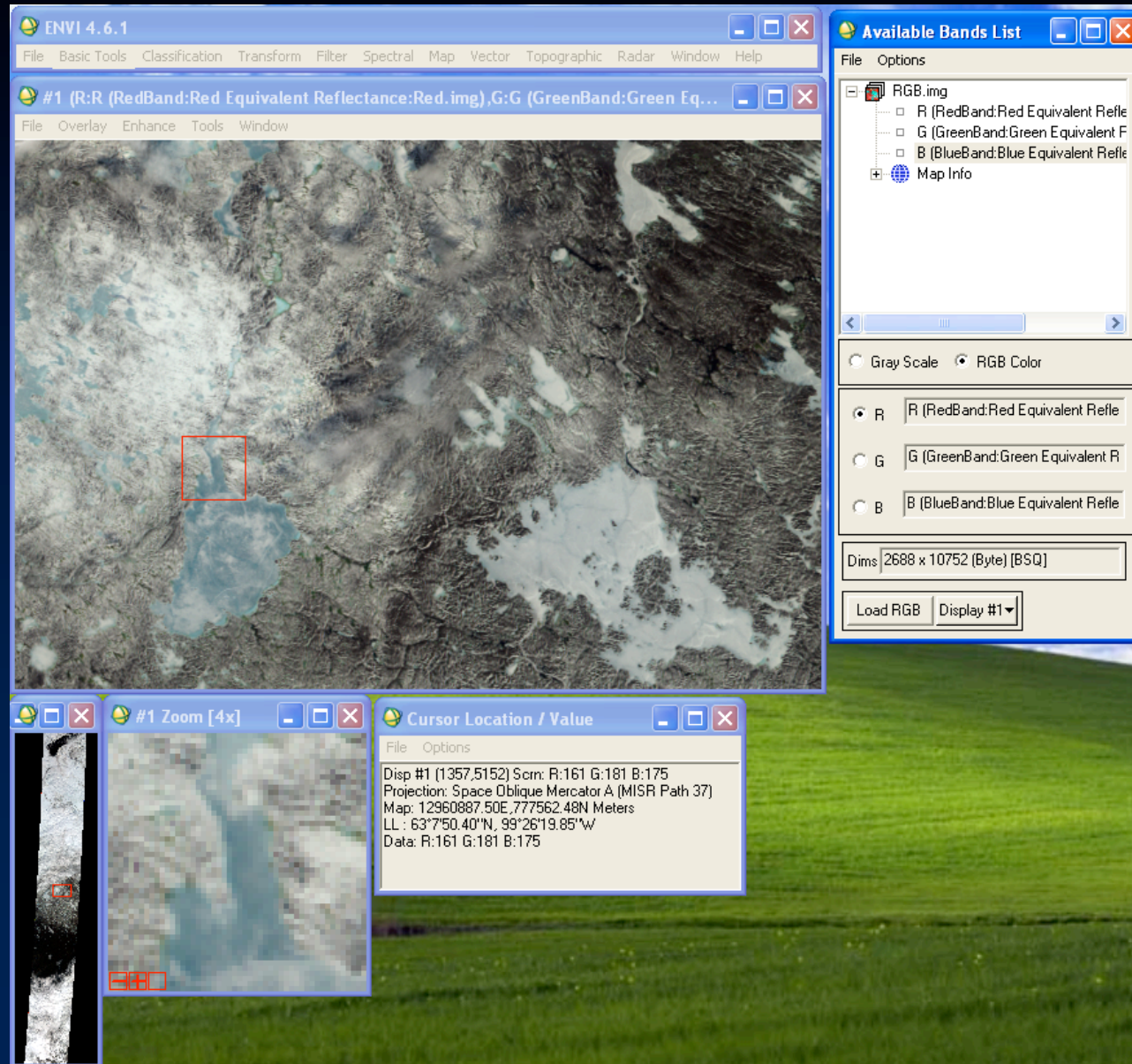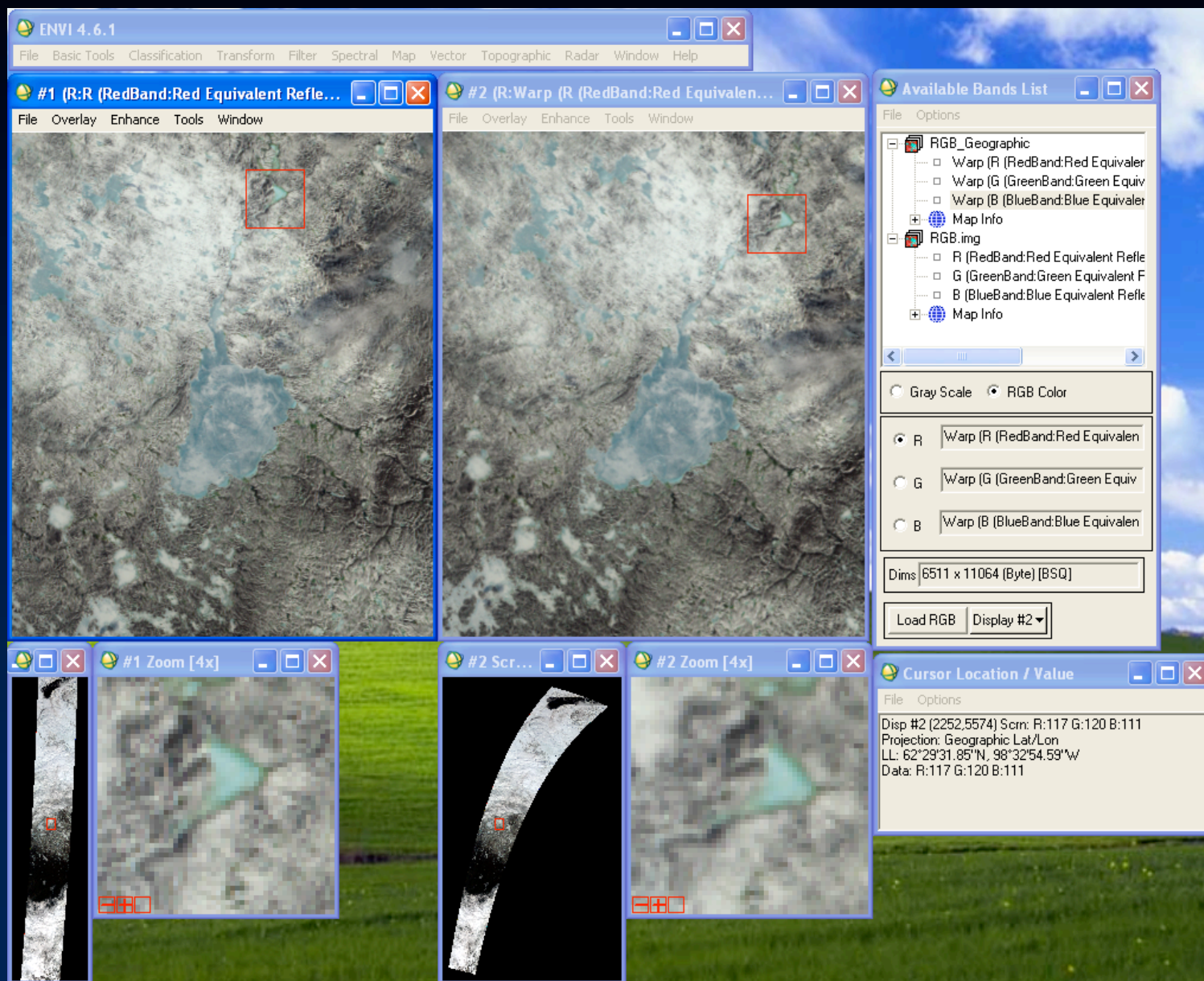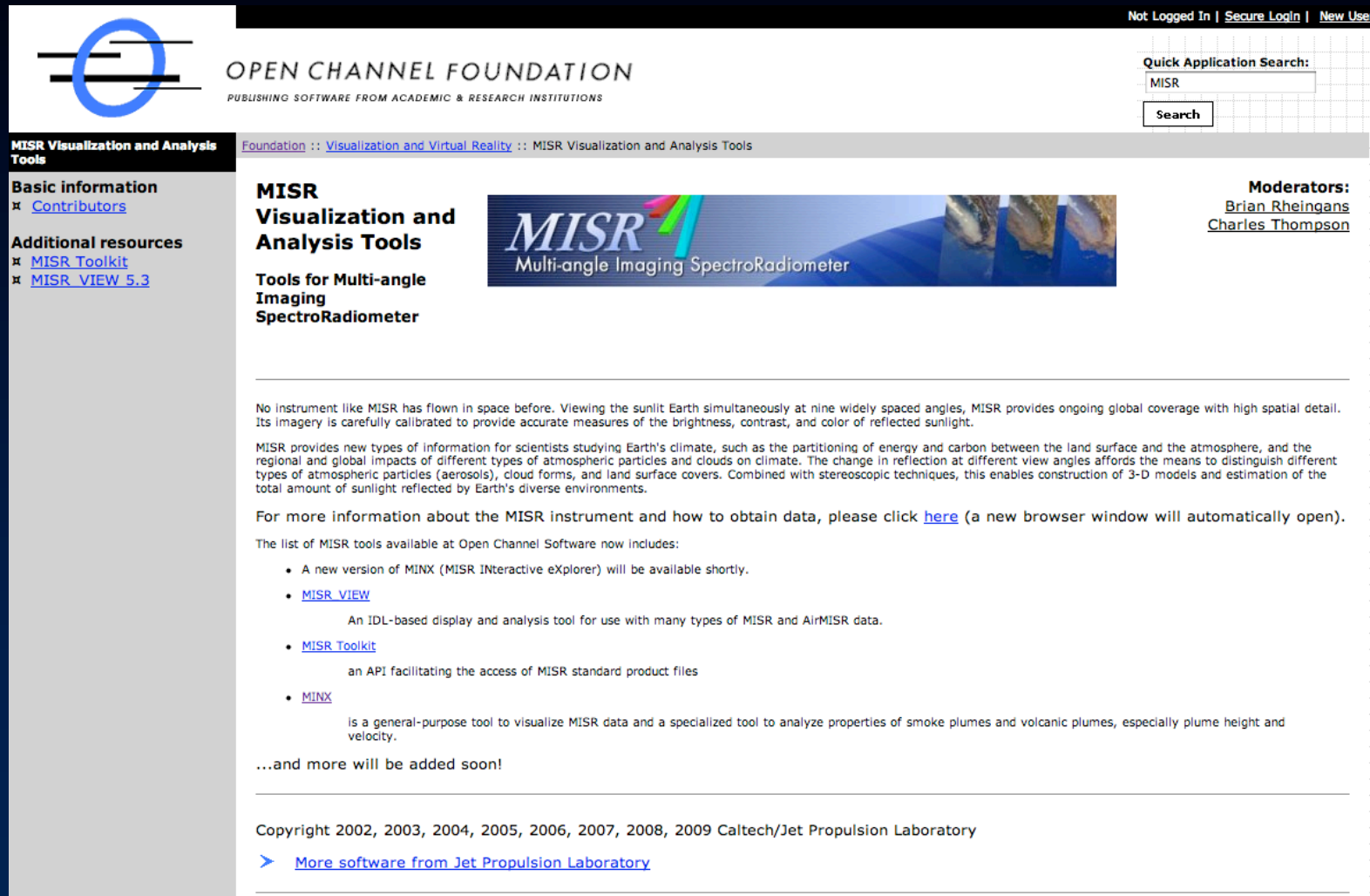
MISR data loaded in ENVI preserving geolocation information

MISR SOM data reprojected to Geographic Lat/Lon using ENVI

Where to get the MISRView, MISR Toolkit and MINX?
Open Channel Foundation

http://www.openchannelsoftware.org
Search for "MISR" in the Quick Applications Search field

Other Tools to access MISR data

Tools for Working with MISR Data Products

ATMOSPHERIC SCIENCE DATA CENTER

MISR

Tool	Description	Data Products (definitions)	Data Format (definitions)	Software Language
Orbit/Date Conversion	Interactive interface for converting dates to MISR Orbit number and Orbit numbers to dates	N/A	N/A	N/A
Lat/Lon to Path/Block Conversion	Interactive interface for obtaining MISR paths based on latitude and longitude	L1, L2	N/A	N/A
MISR Browse Tool	Easy access to ellipsoid projected true-color images for each camera reduced to 2.2 km resolution	Browse	N/A	N/A
MISR INteractive eXplorer (MINX)	Interactive application for visualizing Level 1B2 data and for retrieving plume heights and wind velocities from wildfire smoke, volcanic and dust plumes	L1B2, GP_GMP and AGP required; TC_CLASSIFIERS and AS_AEROSOL recommended	Stacked-block	IDL, C
MISR Toolkit	Simplified programming interface for Level 1B2, Level 2, and Ancillary products	L1B2, L2, Ancillary	Stacked-block, Conventional	Various
misr_view	Visualizes MISR TOA radiances, aerosol, surface, and cloud data products	L1B2, L2	Stacked-block	IDL, IDLVM
IDL Utilities	Routines for extracting data and metadata from Level 1B2, Level 2, and Level 3 products	L1B2, L2, L3	Stacked-block, HDF-EOS Grid (L3 only)	IDL
ENVI Tool	Geolocates and visualizes MISR TOA radiance, Terrain and Ellipsoid projected products and the Level 2 Land BRF parameter	L1B2, L2 (BRF only)	Stacked-block	ENVI
ENVI SOM Instructions	Instructions for setting Space Oblique Mercator map information in ENVI version 4.0	L1B2, L2	Conventional	ENVI
misr_time	Calculates the block center times for MISR Level 1B2 files	L1B2	Stacked-block	IDL, IDLVM
hdfscan	Visualize and explore MISR data products	L1B2, L2, L3	Stacked-block, HDF-EOS Grid (L3 only)	Multiple
HDFView and HDF-EOS plug-in	Tool for browsing and editing NCSA HDF4 and HDF5 files	L1B2, L2, L3	Stacked-block, Conventional, HDF-EOS Grid (L3 only)	Various
Conversion to ASCII	Routines to write parameters from MISR Level 1B2 or AGP data files to a set of ASCII formatted files	L1B2, AGP	Stacked-block	IDL, IDLVM
MISR HDF-to-Binary Converter	HDFDUMP extracts data from a HDF-EOS grid format file (Level 1B2 and Level 2 files) and writes unformatted binary files	L1B2, L2	Stacked-block	FORTRAN 90
Radiance/BRF Calculation Tools	BRFDUMP calculates radiances and bidirectional reflectance factors (BRF) from Level 1B2 files and creates unformatted binary files	L1B2	Stacked-block	FORTRAN 90
HDF-EOS to GIS Format (HEG) Conversion Tool	Reformat, re-project and perform stitching/mosaicing and subsetting operations on HDF-EOS objects	L1B2, L2	Stacked-block	Various
HDF Data Manipulation Software	Applications to open a Hierarchical Data Format (HDF) file	N/A	N/A	Various
Unidata software for manipulating or displaying netCDF data	References to software packages for manipulating or displaying netCDF data	L3	netCDF	Various

http://eosweb.larc.nasa.gov/PRODOCS/misr/tools/misr_tools.html

MISR Multi-path Mosaic

Albers Conic Equal Area Projection
Standard Parallels: 29° 30′ and 45° 30′
Projection Center: 36° N and 92° W

Image credit: NASA/GSFC/LaRC/JPL, MISR Team
Multi-path mosaic by Jim Knighton of Clear Light Image Products (jknighton@clear-light.com)

MISR Multi-path Mosaic

Albers Conic Equal Area Projection
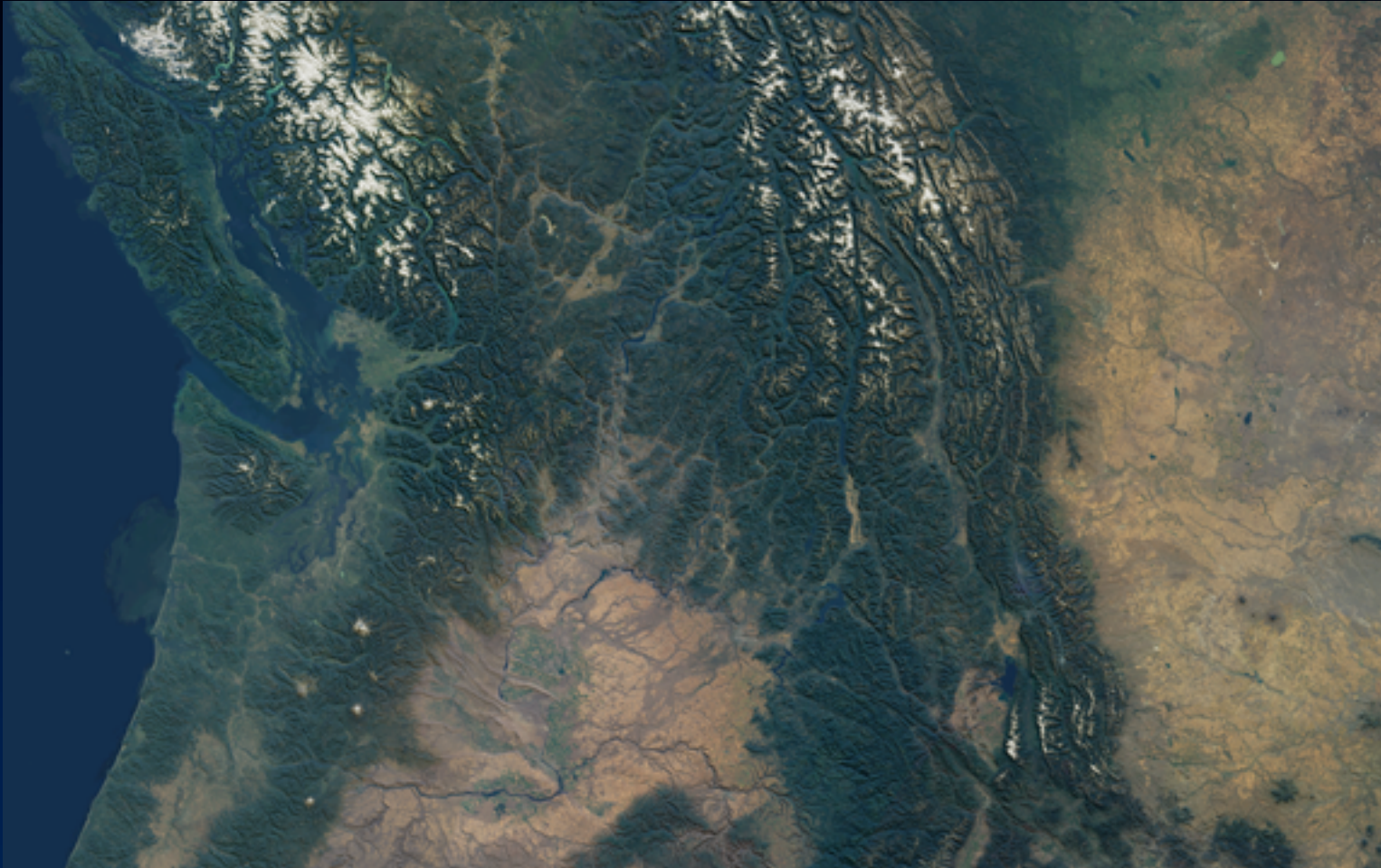**Standard Parallels: 29° 30´ and 45° 30´**
Projection Center: 36° N and 92° W

Image credit: NASA/GSFC/LaRC/JPL, MISR Team
Multi-path mosaic by Jim Knighton of Clear Light Image Products (jknighton@clear-light.com)

MISR Multi-path Mosaic

Albers Conic Equal Area Projection
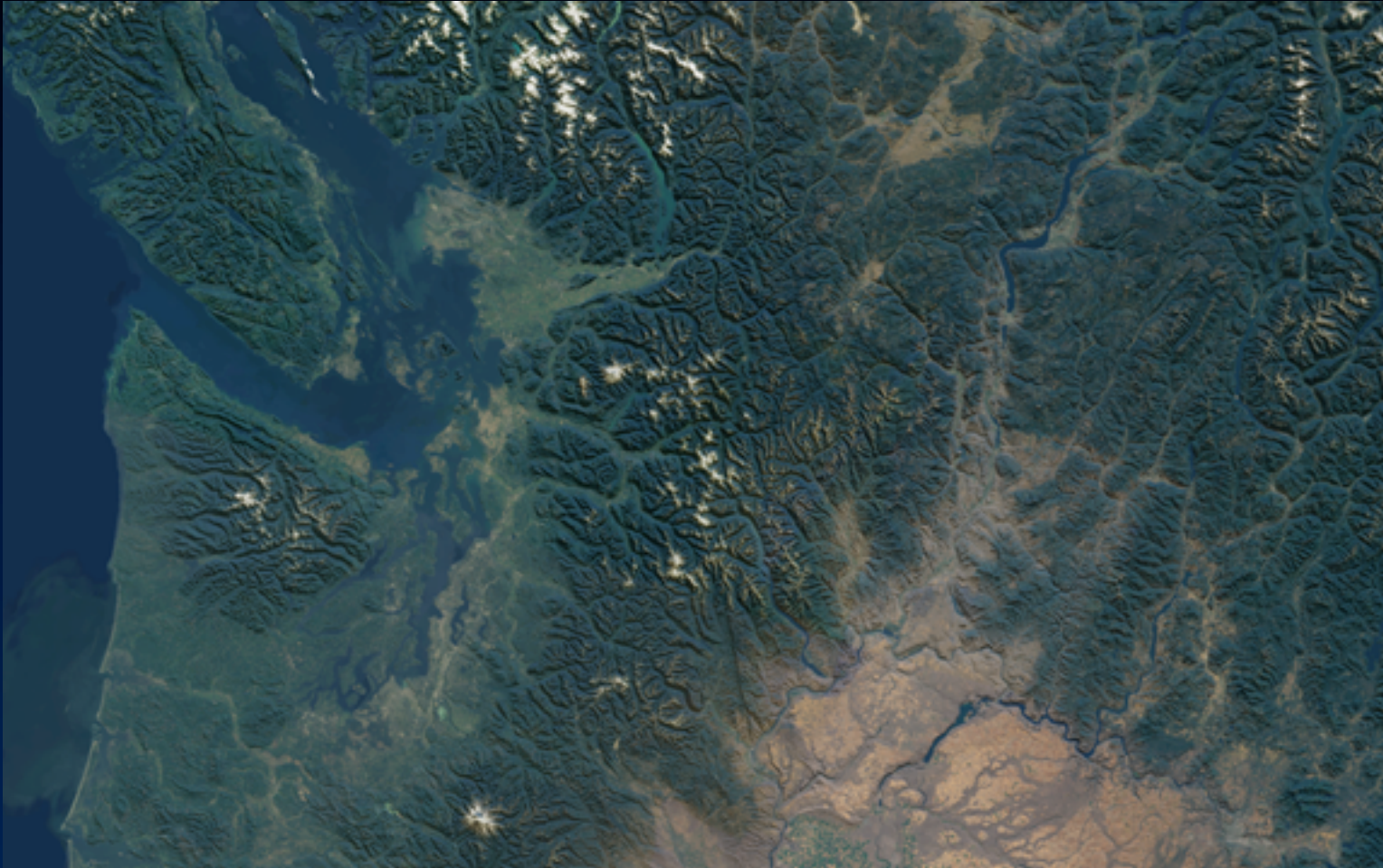**Standard Parallels: 29˚ 30´ and 45˚ 30´**
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Albers Conic Equal Area Projection
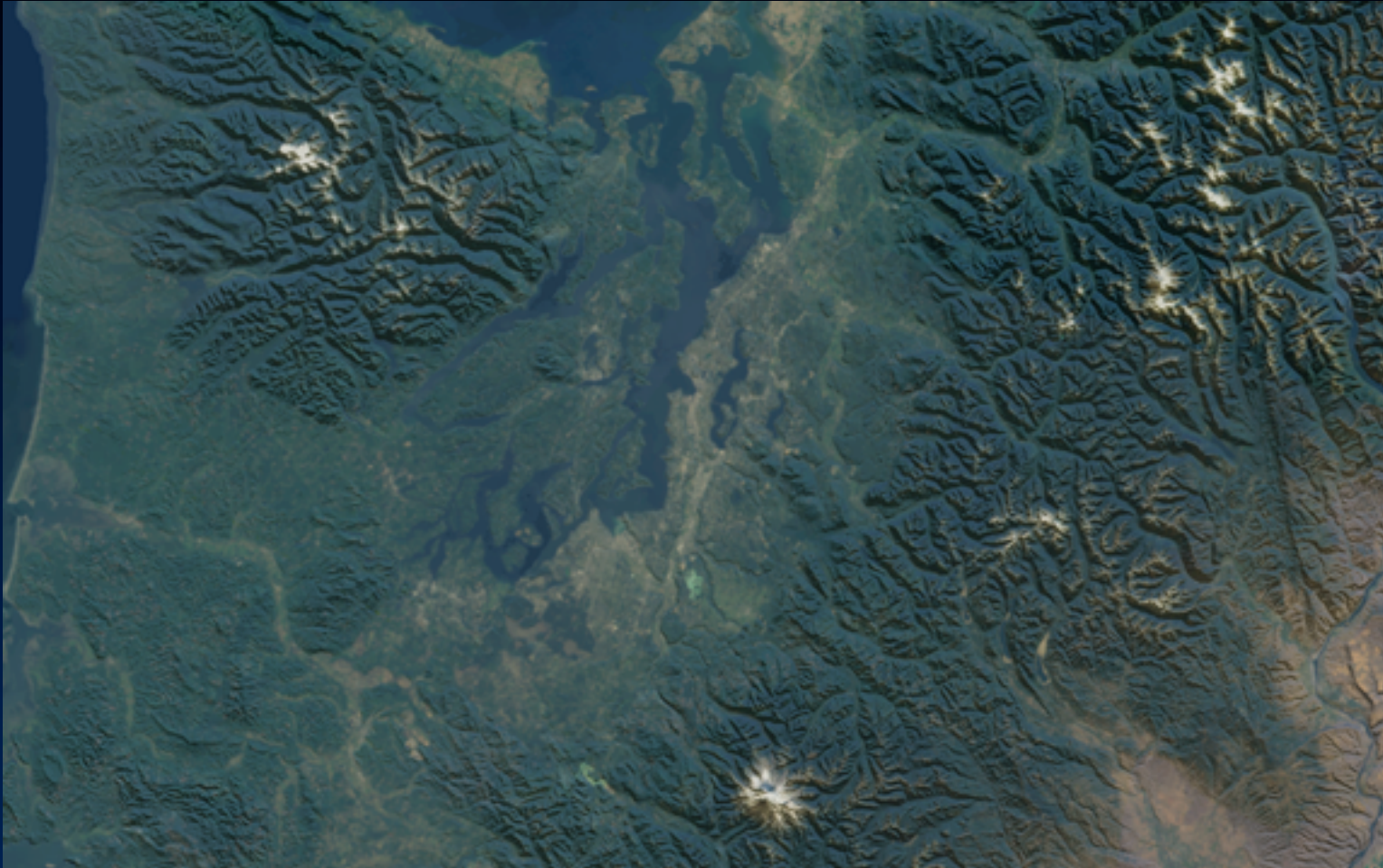**Standard Parallels: 29˚ 30´ and 45˚ 30´**
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